Faunistic Survey of Philippine Freshwater Microcrustacean Zooplankton: New Locality Records and Updated Species Accounts*

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KEY WORDS :

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Copepoda
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Lake Lahit
Lake Taal
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Abstract

This paper updates the taxonomy and distribution of microcrustacean zooplankton belonging to Cladocera and Copepoda from selected freshwater bodies of Luzon Island, Panay Island and South Cotabato, Mindanao Island in the Philippines whose zooplankton fauna have remained undocumented to date. A total of 31 sampling sites were visited including 11 ponds, 5 lakes, 12 rivers, 1 man-made dam, and 2 streams. Zooplankton samples were collected using 80mesh size plankton nets, and processed and identified in the laboratory. Morphological characteristics were examined under light compound, dissecting, and phase-contrast microscopes for taxonomic identification. Results showed that 13 species were present from the different sampling sites with 7 cladocerana and 6 copepods. Further analyses revealed new locality records for *Mesocyclops ogunnus* in Lake Taal and *Arctodiaptomus dorsalis* in Lake Lahit. All species from Lake Holon are new locality records. Results from this study contributed much needed information to make a thorough analysis on the distribution of microcrustacean zooplankton taxa in the Philippines as well as provide the first accounts of microcrustacean zooplankton from Panay Island.

Introduction

The microcrustacean zooplankton taxa Cladocera (Branchiopoda) and Copepoda (Maxillopoda) are important components of tropical freshwater ecosystems. They are both involved in the aquatic functioning by grazing on other small invertebrates as well as algae, and are in turn utilized by zooplanktivorous fishes as food (Ludwig, 1999; Mitra et al., 2007).

There are 117 species of freshwater microcrustacean zooplankton recorded in the Philippines which includes 82 cladocerans, and 35 copepods (15 from Order Calanoida and 20 from Order Cyclopoida) listed in several publications. The data include the seminal works of Philippine zooplankton by Mamaril & Fernando (1978), Mamaril (1986), and Mamaril (2001). The most recent studies of freshwater microcrustacean zooplankton taxonomy and distribution in the Philippines were published by Papa et al. (2012), Papa & Holynska (2013), Pascual et al. (2014) and Dela Paz et al. (2016).

Recent studies on zooplankton done by Pascual et al. (2014) overlooked some key biodiversity areas such as Panay island and many parts of Mindanao; while some localities in Luzon have been sampled for zooplankton but many of the collected specimens have yet to be identified to species level. This includes Lake Taal, which, in spite of the increased number of scientific publications and surveys conducted on many components of its biodiversity (e.g. Mamaril [1986, 2001]), still yields new records even for relatively well-studied such as the Copepoda.

This paper aims to update and add information on the freshwater microcrustacean zooplankton fauna of the Philippines after extensive sampling on Lake Taal in Luzon Is., three provinces (Aklan, Antique and Capiz) on Panay Is. and the province of South Cotabato on Mindanao Is.

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Materials and Methods

Study sites. A total of 31 freshwater ecosystems comprising of 11 ponds, 5 lakes, 12 rivers, 1 dam, and 2 springs was sampled during the month of June 2014 in Aklan, Capiz, and Antique and South Cotabato (Table 1, Figure 1). Previously collected samples in the UST Zooplankton Reference Collection (UST-ZRC) from Lake Taal were re-analyzed for possible new records.

Collection of samples. Zooplankton collection was done in replicates using a 80 mesh plankton net. Conical plankton net was towed obliquely and vertically covering both the littoral and limnetic zones, respectively. Samples were preserved using 70% EtOH and placed in properly labeled capped bottles. The samples were brought to the University of Santo Tomas Biology Laboratory for identification and analysis.

Sample processing. Each specimen was dissected a under Swift stereomicroscope using tungsten needles. The specimens were mounted in slides using glycerin as the mounting medium, examined using an Olympus CX21 compound microscope, and drawn with the aid of an Olympus U-DA drawing attachment. The description and taxonomic note of the species were generated as guide for future workers. Only important diagnostic characters for identification were provided.

Identification of samples. Identification was done with the aid of taxonomic keys and illustrations on Philippine zooplankton by Goulden (1968), Fryer (1968), Mamaril Sr. & Fernando (1978), Berner (1985), Mamaril (1986), Korovchinsky (1992), Smirnov (1996), Dussart & Defaye (2001), Dumont & Negrea (2002), Fernando (2002), Korovchinsky (2002), Boxshall and Halsey (2004), Hołyńska (2000), Mirabdullayev et al. (2003), Papa et al. (2012a), Papa & Hołyńska (2013), and Dela Paz et al. (2016).

Results and Discussion

Species composition. Thirteen species of freshwater planktonic microcrustacean from five provinces (Aklan, Antique, Batangas, Capiz, and South Cotabato) were observed. These include seven cladocerans, five cyclopoid, and one calanoid species (Table 3). *Diaphanosoma excisum* Sars, 1885 was observed in most of the sampling sites. Seven species, *Chydorus* cf. *sphaericus* (Mueller, 1785), *Ceriodaphnia cornuta* Sars, 1885, *Diaphanosoma sarsi* Richard, 1894, *Diaphanosoma tropicum* Korovchinsky, 1998, *Mesocyclops ogunnus* Onabamiro, 1957, *Thermocyclops crassus* (Fischer, 1853), and *Arctodiaptomus dorsalis* (Marsh, 1907), were encountered in one locality each. Important morphological characters are listed and described below (Table 2).

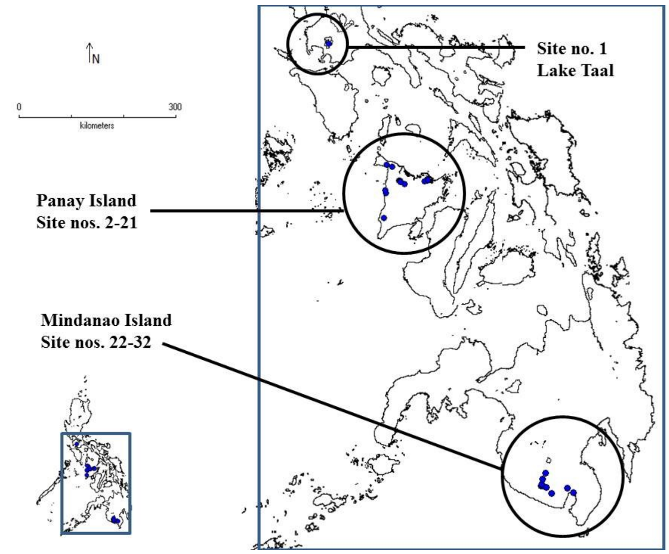


Figure 1. Map of the Philippines indicating sampling sites of this study. Refer to Table 1 for other pertinent details on the sampling sites.

Distribution and occurrence. The seven cladocerans identified are new locality records in their respective areas of collection except for the moinid *Moina micrura* Kurz, 1875 from Lakes Sebu and Siloton, and *Diaphanosoma excisum* from Lake Siloton. *D. excisum* is the most common species of Cladocera collected in most sampling sites. It is widely distributed in 10 freshwater bodies of Panay and Mindanao islands (Figure 2, Table 3) and is a common planktonic species throughout the tropics (Mamaril and Fernando, 1978; Korovchinsky & Sanoamuang, 2008) and one of the more adaptable sidids that tend to regularly thrive in aquaculture sites (Pascual et al., 2014). It is noteworthy that Lake Holon contains the most number of cladocerans including *C. cornuta, D. excisum,* and *D. tropicum* which are all new records in the area. The efficiency of cladocerans as filter-feeders of phytoplankton and other small organisms together with low fish biomass may have played a role in the high water transparency of the lake compared to the other three lakes in the region. The altitude of the lake (Rautio, 1998; Sarnelle & Knapp, 2004) may be preventing introduction of zooplankton through usual means (fish co-introductions) and may rely more on passive dispersal through bird droppings (Mamaril & Fernando, 1978). Furthermore, the lack of intensive aquaculture in the lake meant that there are fewer sources of turbidity (Olopade, 2013) in Lake Holon. Further studies and conservation measures have to be put up in this lake to ensure that it maintains its mark as one of the "cleanest lakes" in the country.

The three identified sidids in this study such as *D. sarsi, D, excisum*, and *D. tropicum* were also common species of cladocerans in Thailand (Korovchinsky & Sanoamuang, 2008) and previously observed in several inland waters in the islands of the Philippines (Pascual et al., 2014). Few of

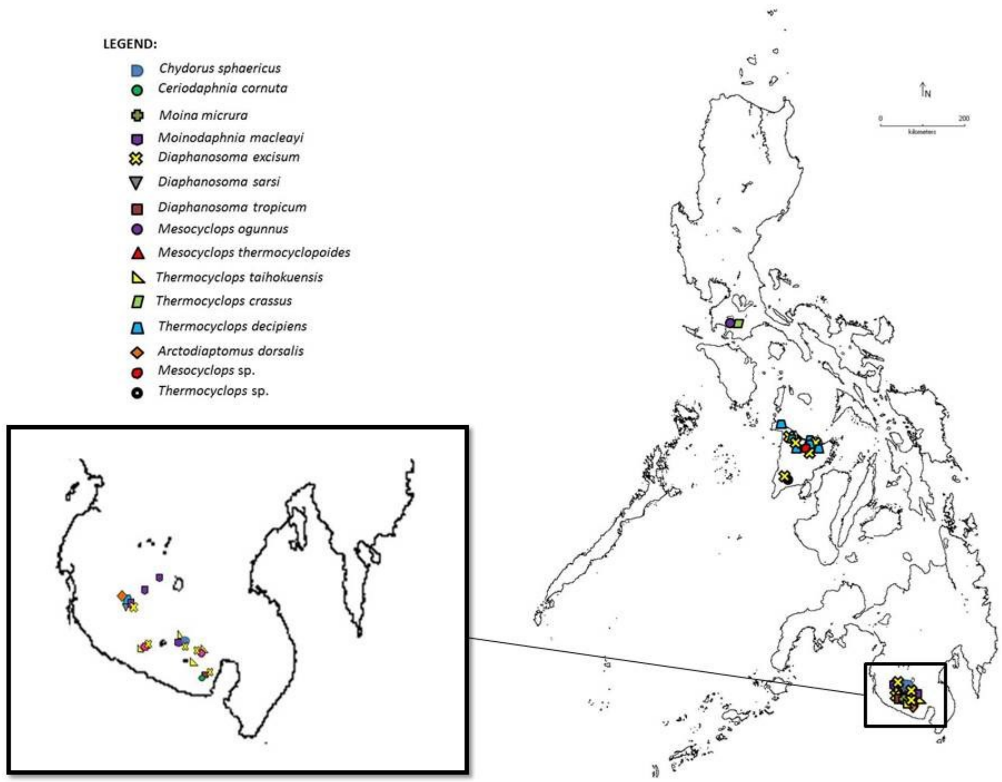


Figure 2. Geographic distributions of Cladocera and Copepoda observed in this study.

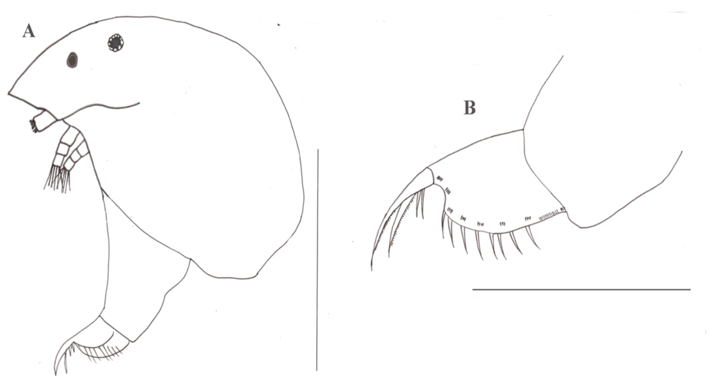
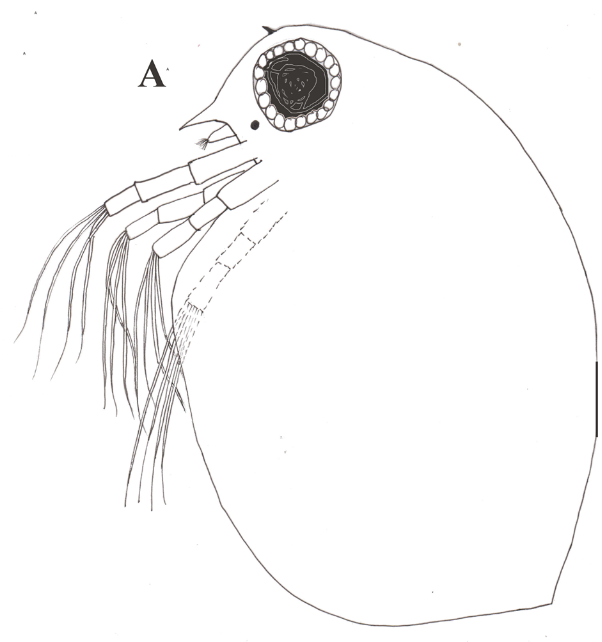
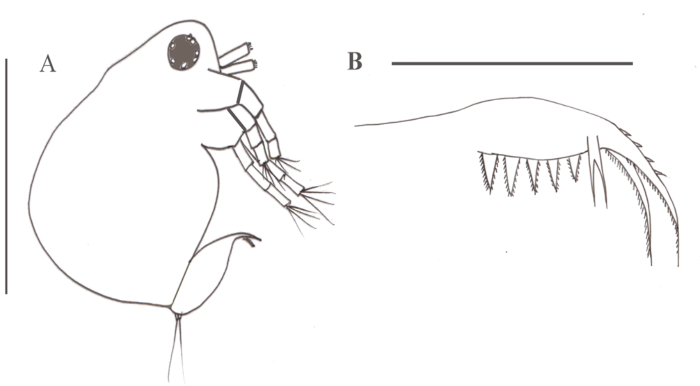


Figure 3. *Chydorus* cf. *sphaericus* A, habitus; B, postabdomen. (Scale bar: A= 250 µm; B= 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0195A.





↑Figure 4. *Ceriodaphnia cornuta* A, habitus. (Scale bar = 250 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0194A.

←Figure 5. *Moina micrura* A, habitus; B, postabdomen. (Scale bar: A, 125 µm; B, 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers 0192A-0193A.

Table 1. List of different sampling localities in this study.

	Area of Collection	Municipality	Province	Island
1	Lake Taal	Taal	Batangas	Luzon
2	Lake Laguna	Malay	Aklan	Panay
3	Aklan River	Libacao	Aklan	Panay
4	Dalanas River	Tibiao	Antique	Panay
5	Fishpond at Brgy. Julita	Libacao	Aklan	Panay
6	Fishpond at Brgy. Sublangon	Pontevedra	Capiz	Panay
7	Fishpond at Brgy. Tumalalud	Mambusao	Capiz	Panay
8	Fishpond at Brgy. Guadalupe A	Libacao	Aklan	Panay
9	Fishpond at Brgy. Guadalupe B	Libacao	Aklan	Panay
10	Ibajay River	Ibajay	Aklan	Panay
11	Lagoon at Brgy. Julita	Libacao	Aklan	Panay
12	Mambusao Dam	Mambusao	Capiz	Panay
13	Mangayaw Falls	Libacao	Aklan	Panay
14	Panay River	Libacao	Aklan	Panay
15	Panitan River	Panitan	Capiz	Panay
16	Pond at Brgy. Tabuc	Pontevedra	Capiz	Panay
17	Pond at District 3	Sibalom	Antique	Panay
18	Sibalom's Jose Irrigation Water System	Sibalom	Antique	Panay
19	Spring in Brgy. Guia	Pandan	Antique	Panay
20	Tamarog River	Libertad	Antique	Panay
21	Tibiao River	Tibiao	Antique	Panay
22	Lake Sebu	Lake Sebu	South Cotabato	Mindanao
23	Lake Siloton	Lake Sebu	South Cotabato	Mindanao
24	Lake Lahit	Lake Sebu	South Cotabato	Mindanao
25	Lake Holon	T'boli	South Cotabato	Mindanao
26	Allah River	Surrallah	South Cotabato	Mindanao
27	Banga River	Banga	South Cotabato	Mindanao
28	Brgy. New Dumangas Pond A	T'boli	South Cotabato	Mindanao
29	Brgy. New Dumangas Pond B	T'boli	South Cotabato	Mindanao
30	Brgy. New Dumangas Pond C	T'boli	South Cotabato	Mindanao
31	Klinan River	General Santos City	South Cotabato	Mindanao
32	Buayan River	General Santos City	South Cotabato	Mindanao

Table 2. Important morphological characters of each observed species.

SPECIES	DESCRIPTION
Class Branchiopoda Superorder Cladocera Order Anomopoda Stebbing, 1902 Family Chydoridae Dybowski & Grochowski, 1894	
Chydorus cf. *sphaericus* (Mueller, 1875)	The body is sub-globular (Figure 3A). Rostrum is pointed with a notched tip. Antennule is much shorter than its rostrum. Antennal segments have small spines. Labrum is cuneiform with relatively elongated tip. Post abdomen short with 8-10 anal teeth (Figure 3B); Terminal claw with two basal spines (Figure 3B).
Family Daphniidae Straus, 1820	
Ceriodaphnia cornuta Sars, 1885	Oval shape head produced in front of antennules into a short, conical, sharp-pointed horn-like process and with a pigmented patch of ocellus (Figure 4A). Antennae with fine hairless spines. Postabdomen rounded on dorsal side and postabdominal claws with fine ciliation.
Family Moinidae Goulden 1968	
Moina micrura Kurz, 1974	Hairs are absent on the head (Figure 5A). The antennules form a knob-like shape (Figure 5A). Sensory papillae are prominent and long. The exopod bearing setae reaching second to fourth segment. Postabdomen is short and slender bearing long hairs (Figure 5B).
Moinodaphnia macleayi King, 1853	Hairs are absent on the sub-triangular head (Figure 6A). Large eyes are located near the margin of the head. Ocellus is present below the eye near the antennules. Antennules are long and thing with 9 sensory papillae at the distal end. The first antennae with exopod has the distal segment with three setae. Bident tooth present on the postabdomen with unequal spines (Figure 6B).
Order Ctenopoda Sars, 1865 Family Sididae Baird, 1850	
Diaphanosoma excisum Sars, 1885	Hemispherical carapace (Figure 7A). Massive; Distal end of the basipodite of the antennae with small sharp spine; Proximal segment of the first and second segment of the antennal branches with a stout spine. Two of the terminal claws of the post abdomen of the same size (Figure 7B). Narrow postero-ventral free flap with ungrouped feathered margins (Figure 7C).
Diaphanosoma sarsi Richard, 1894	Rectangular head (Figure 8A). Large eyes that occupies head part. Swimming antennae short and weak with a stout spine on the outer part of the distal end of its basipodite and a noticeable sharp spine in the apical ends of the first and second segments of the upper segmented antennal branch. Post-abdomen with rows of setules and spinules on its sides (Figure 8B). It has a broad postero-ventral valve margin bearing feathered and naked setae (Figure 8C).
Diaphanosoma tropicum Korovchinski, 1998	Triangular head (Figure 9A). Antennae bearing a prominent spine. Ends of the distal segment with comparatively large and noticeably curved spine often having hook like appearance. The postabdomen has very prominent or strongly convex shape (Figure 9B). The postero-ventral margin bearing ungrouped spines dorsally with setae between them (Figure 9C).

Cont'd. Table 2.

SPECIES	DESCRIPTION
Order Calanoida Sars, 1903 Family Diaptomidae Baird, 1850	
Arctodiaptomus dorsalis (Marsh, 1907)	Female: Body clearly segmented and elongated and narrows between the segments bearing the 5th legs and genital segment. Both antennules straight. P5 has an endopod that is nearly as long as the exopodite 1; P5 symmetrical (Figure 10A). Male: Right antennule geniculate. P5 has a lateral spine inserted proximal to the middle of the right of exopodite 2 where the said spine is longer than the exopodite 2; P5 asymmetrical (Figure 10B).
Class Maxillopoda Superorder Podoplea Order Cyclopoida Burmeister, 1835 Family Cyclopidae Rafinesque, 1815 Subfamily: Cyclopinae Rafinesque, 1815	
Mesocyclops ogunnus, Onabamiro 1957	Adult Female. Body narrows down between the 4th and 5th segment. Insertion of spinules may be present or absent in the lateral caudal setae, but always present in the insertion of the lateralmost caudal setae (Figure 11A). Genital double somite is longer than wide (Figure 11B). The lateral arms of seminal receptacle is wide and short (Figure 11B). Transverse duct-like structure forms an obtuse angle before the copulatory pore (Figure 11B). Antennule with 17 segments reaching posterior margin of p3 (Figure 11C). P5 spine is inserted in the middle of the inner margin (Figure 11D). Hairs are present at the dorsal segment of pediger 5 (Figure 11E). Large spinules are present at the maxillulary pulp. Subequal length of apical spines of p4 endopodite 3 (Figure 11F).
Mesocyclops thermocyclopoides Harada, 1931	Adult Female. Body narrows down between the 4th and 5th segment. Genital double somite is longer than wide. Lateral arms of seminal receptacle short and wide. Transverse duct-like structure forming a straight line next to the copulatory pore. Antennule with 17 segments reaching posterior margin of p3. P5 spine is inserted in the middle of the inner margin. No spinules present at the insertion of lateral and lateralmost caudal setae. Maxillulary pulp without spinules. Subequal length of apical spines of p4 endopodite 3.
Thermocyclops taihokuensis (Harada, 1931)	Adult Female. Body narrows down between the 4th and 5th segment. No spinules at the insertion of lateral caudal setae and lateralmost caudal setae (Figure 12A). Genital double somite is longer than wide (Figure 12B). Lateral arms of seminal receptacle is strongly curved posteriorly (Figure 12B). Antennule with 17 segments reaching posterior margin of p3. P5 spine is inserted distally near seta (Figure 12C). The medial margin of p4 basipodite bears spinules (Figure 12D). The intercoxal sclerite bearing two rows of hairs on caudal surface (Figure 12D). Hemispherical outgrowth at the intercoxal sclerite bears few teeth (Figure 12D). The p4 exopodite 3 bears I-II,1-3 armature formula (Figure 12E) Prominent apical spines of p4 endopodite 3 have different length (Figure 12F).
Thermocyclops crassus (Fischer, 1853)	Adult Female. Body narrows down between the 4th and 5th segment. No spinules at the insertion of lateral caudal setae and lateralmost caudal setae (Figure 13A). Genital double somite is longer than wide (Figure 13B). Lateral arms of seminal receptacle is wide and straight, almost forming a "T" shape (Figure 13B). Antennule with 17 segments reaching posterior margin of p2. P5 spine is inserted distally near seta. The tip of the medial median terminal caudal setae is coiled (Figure 13A). The medial margin of

Cont'd. Table 2.

SPECIES	DESCRIPTION
	p4 basipodite bears hairs (Figure 13C). The intercoxal sclerite bearing two rows of hairs, caudal surface (Figure 13C). Hemispherical outgrowth at the intercoxal sclerite bears prominent teeth (Figure 13C). Apical spines of p4 endopodite 3 have different length (Figure 13D).
Thermocyclops decipiens (Kiefer, 1929)	Adult Female. Body narrows down between the 4th and 5th segment. No spinules at the insertion of lateral caudal setae and lateralmost caudal setae (Figure 14A). Genital double somite is longer than wide (Figure 14B). Lateral arms of seminal receptacle is slightly curved posteriorly (Figure 14B). Antennule with 17 segments reaching posterior margin of p2. P5 spine is inserted distally near seta. The medial margin of p4 basipodite bears spinules (Figure 14C). The intercoxal sclerite bearing two rows of hairs on caudal surface (Figure 14C). Triangular shape outgrowth at the intercoxal sclerite bears prominent teeth (Figure 14C). Apical spines of p4 endopodite 3 have different length.

species of cladocera including *D. excisum* and *C. cornuta* are present in Australia (Smirnov & Timms, 1983; Korovchinsky & Timms, 2011). The wide zoogeographical range of this group of zooplankton throughout Australasia confirms its good dispersal capabilities.

Some earlier recorded species have not been found in our study such as the bosminid *Bosmina fatalis* Burckhardt, 1924 from Lakes Sebu, Siloton, and Lahit, the chydorid *Ephemeroporus barroisi* (Richard, 1894) in Lakes Sebu and Siloton, and the moinid *M. micrura* in Lake Lahit (Pascual et al., 2014). Freshwater microcrustacean zooplankton community is a dynamic system in which species composition is significantly affected by the changing season, food availability, the presence of predator and existing competition (Pagano et al., 2003; Guevara et al., 2009; Brakovska et al., 2013).

The invasive calanoid *A. dorsalis*, which was previously only found in Lakes Sebu and Siloton (Papa et al., 2012) was also collected from nearby Lake Lahit (Figure 2, Table 3). This copepod is the most common and dominant calanoid in most inland waters in Luzon (Papa et al., 2012; Papa et al., 2012a; Rizo et al., 2015). Given the proximity and interconnection between these three lakes it is not surprising for *A. dorsalis* to have been collected from Lake Lahit as well. This is in spite of not finding *A. dorsalis* from Lakes Sebu and Siloton during this sampling trip, which may be due to increased predation pressure from juvenile cultured fishes such as *Oreochromis niloticus*, which may have caused a decline in *A. dorsalis* populations. This finding also expanded the distribution of *A. dorsalis* and confirmed its occurrence in lakes heavily utilized for aquaculture in Mindanao (Papa et al., 2012a; Metillo et al., 2015).

Current analyses of Lake Taal specimens yielded a new locality record of *M. ogunnus* which co-existed with *T. crassus* (Figure 2, Table 3). *M. ogunnus* inhabits small, large, deep, ponds and other kinds of water bodies (Hołyńska, 2003). Lake Taal is the third largest lakes in the country which is home to a diverse group of flora and fauna (Mamaril 2001; Papa et al., 2008; Papa & Zafaralla, 2011). The water quality and other limnological characteristics there are highly influenced by aquaculture, agriculture and commercial activities in the watershed, with nutrient input from the previous or persisting volcanic activity which had contributed to the current conditions in the lake (Papa et al., 2011; Papa & Zafaralla, 2011). Hence, we cannot exclude the introduction of *M. ogunnus* in the area due to fish co-introductions, bird droppings, or human-mediated activities. The two cyclopoids, *M. ogunnus* and *T. crassus,* are highly utilized and consumed by the zooplanktivorous fishes in the lake being an important component of the aquatic food chain (Magsino, 2012).

A new locality record of *Thermocyclops taihokuensis* (Harada, 1931) has been observed in Lake Sebu, Lake Siloton, Ponds A and B in Brgy. New Dumangas (T'boli) (Figure 2, Table 3). This species was first encountered in Luzon by Papa & Hołyńska (2013) and followed by Dela Paz et al. (2016) in Leyte Is. The distribution of *T. taihokuensis* in Mindanao may be due to fish stocking and human-mediated activities since these sites are exposed to fishery. The distance of the basins is an important factor as well for possible transfer of the species. The areas of collection are close to one another and may share more or less the same watershed, airshed and human interference thus they might reveal shared species because of possible co-introduction.

In Panay, two cyclopoids were observed, *Mesocyclops thermocyclopoides* Harada, 1931 and *Thermocyclops decipiens* (Kiefer, 1929) which are all new records in the island (Figure 2, Table 3). The occurrences of two species of cyclopoid copepods in freshwater ecosystems in Panay Island have been described and discussed by Dela Paz et

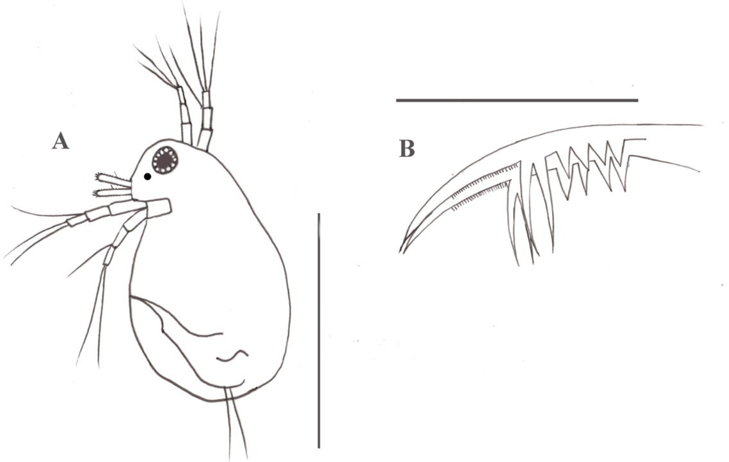
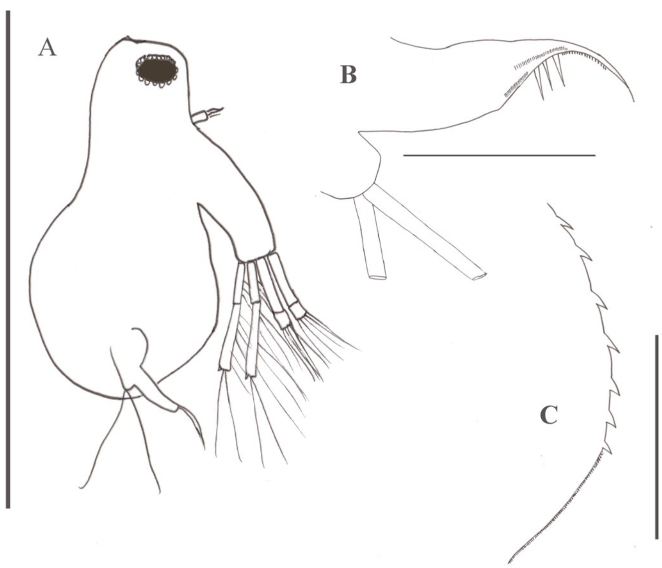
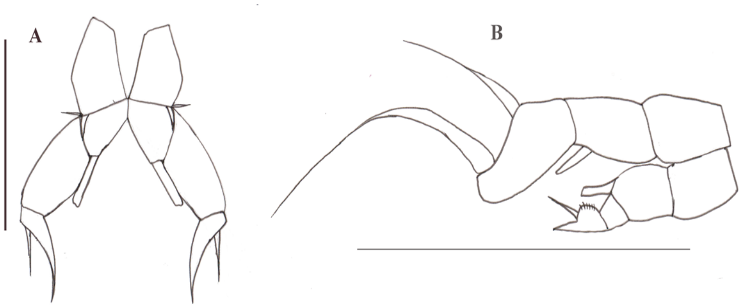


Figure 6. *Moinodaphnia macleayi* A, habitus; B, post-abdomen. (Scale bar= A, 500 µm; B, 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0184A-D.



Figiure 7. *Diaphanosoma excisum* A, habitus; B, post-abdomen; C, postero-ventral valve margin. (Scale bar= A, 250 µm; B-C, 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0185A-B.



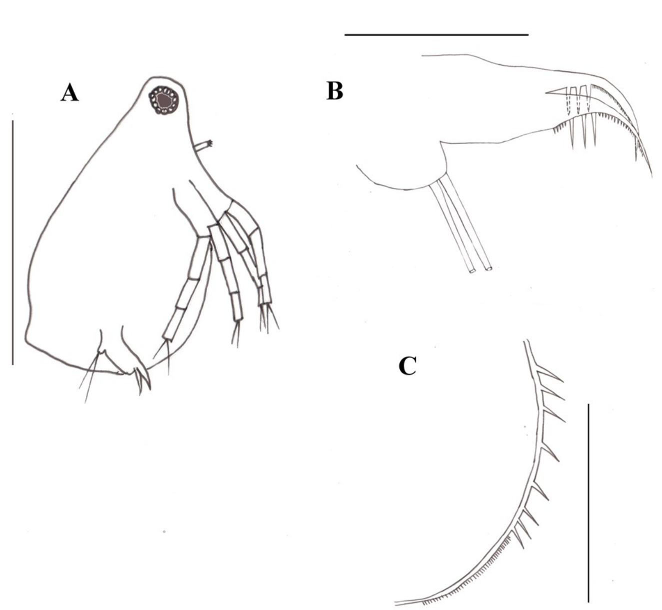


Figure 8. *Diaphanosoma sarsi* A, habitus; B, post-abdomen; C, postero-ventral valve margin. (Scale bar= A, 500 µm; B-C, 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0191A.

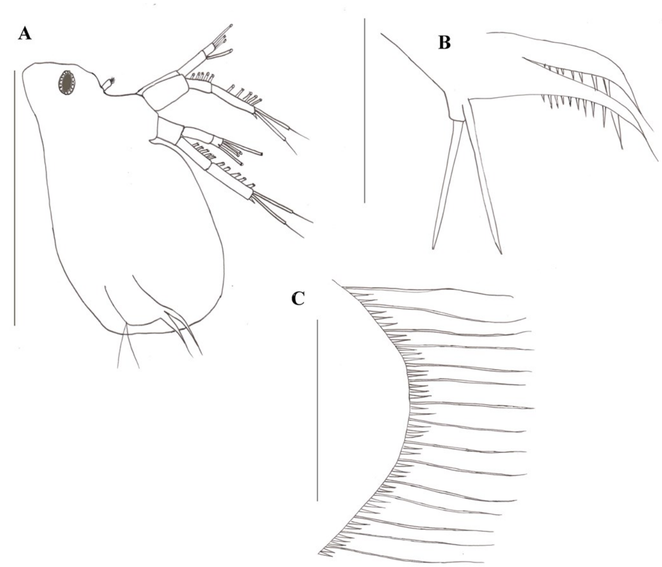


Figure 9. *Diaphanosoma tropicum*, A, habitus; B, postabdomen; C, postero-ventral valve margin. (Scale bar= A, C, 100 µm; B, 250 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0190A.

←Figure 10. *Arctodiaptomus dorsalis* A, Female p5; B, Male p5. (Scale bar= A, 125 µm; B, 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0183A-G.

Table 3. List of the Cladocera and Copepoda observed in this study with their respective distribution.

Species	Luzon	Panay	Mindanao	Description/ Identification key
Chydorus cf. *sphaericus*			12	Petersen and Carlos (1984) Fryer (1968) Fernando (1992) Smirnov (1996) Dumont & Negrea (2002)
Ceriodaphnia cornuta			14	Petersen and Carlos (1984) Berner (1985) Fernando (1992) Dumont & Negrea (2002)
Moina micrura			11, 17	Petersen and Carlos (1984) Fernando (1992) Goulden (1968) Dumont & Negrea (2002)
Moinodaphnia macleayi			12, 13, 15, 16	Petersen and Carlos (1984) Fernando (1992) Dumont & Negrea (2002)
Diaphanosoma excisum		3, 4, 6, 8, 10	11, 12, 13, 14, 17	Mamaril Sr. & Fernando (1978) Petersen and Carlos (1984) Fernando (1992) Korovchinsky (2002) Pascual et al. (2014) Dumont & Negrea (2002)
Diaphanosoma sarsi			13	Pascual et al. (2014) Fernando (1992) Dumont & Negrea (2002)
Diaphanosoma tropicum			14	Pascual et al. (2014) Fernando (1992) Korovchinsky (1992) Dumont & Negrea (2002)
Arctodiaptomus dorsalis			13	Dussart and Defaye (2001) Papa et al. (2012a)
Mesocyclops ogunnus	1			Hołyńska (2000)
Mesocyclops thermocyclopoides		4, 8		Hołyńska (2000) Hołyńska et al. (2003) Dela Paz et al. (2016)
Thermocyclops taihokuensis			11, 12, 17, 18	Mirabdullayev et al. (2003) Dela Paz et al. (2016)
Thermocyclops crassus	1			Mirabdullayev et al. (2003) Dela Paz et al. (2016)
Thermocyclops decipiens		2, 4, 6, 7, 8	13	Mirabdullayev et al. (2003) Dela Paz et al. (2016)
Mesocyclops sp.		9		Boxshall and Halsey (2004)
Thermocyclops sp.		10		Boxshall and Halsey (2004)

1, Lake Taal; 2, Lake Laguna; 3, Aklan River; 4, Fishpond at Brgy. Sublangon; 5, Fishpond at Brgy. Tumalalud; 6, Mambusao Dam; 7, Mangayaw Falls; 8, Panitan River; 9, Pond at Brgy. Tabuc; 10, Pond at District 3; 11, Lake Sebu; 12, Lake Siloton; 13, Lake Lahit; 14, Lake Holon; 15, Allah River; 16, Banga River; 17, Brgy. New Dumangas Pond A; 18, Brgy. New Dumangas Pond C

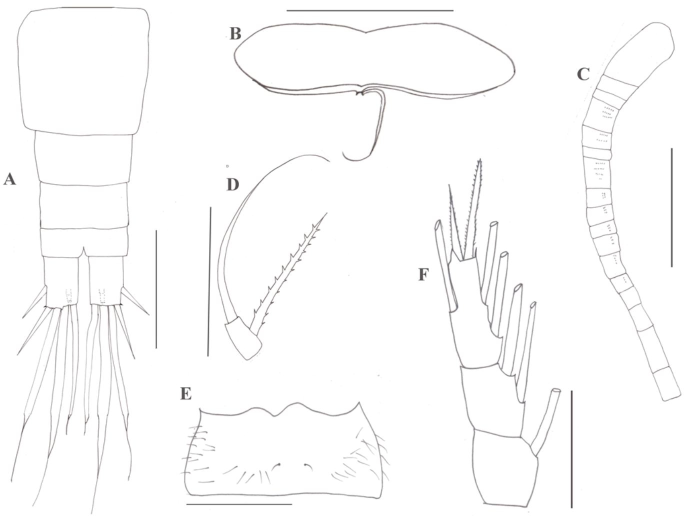


Figure 11. *Mesocyclops ogunnus* A, urosome, ventral; B, lateral arms of seminal receptacle, ventral; C, Antennule; D, p5 leg; E, pediger 5, dorsal; F, p4 endopodite 3. (Scale bar= A, C, F, 100 µm; B, D, E, 50 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0177.

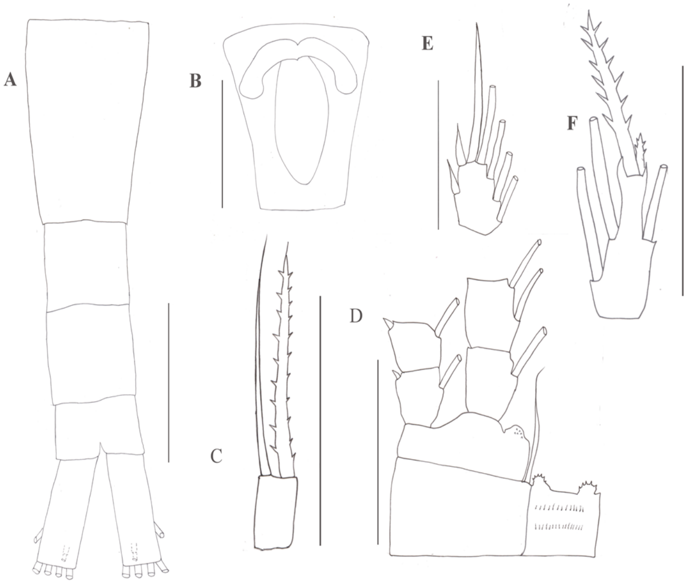


Figure 12. *Thermocyclops taihokuensis* A, urosome, frontal; B, Genital double somite and lateral arms of seminal receptacle, ventral; C, p5 leg; D, p4 intercoxal sclerite, exopodite 2-3 and endopodite 2-3, frontal; E, p4 exopodite 3, frontal. (Scale bar= A-E, 100 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0177A-R.

→**Figure 14.** Thermocyclops *decipiens* A, urosome, ventral; B, Genital double somite and lateral arms of seminal receptacle, ventral; C, p4 Intercoxal sclerite, exopodite 2-3 and endopodite 2-3, frontal. (Scale bar= A, 250 µm; B-C, 100 µm) The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0181A-0181F.

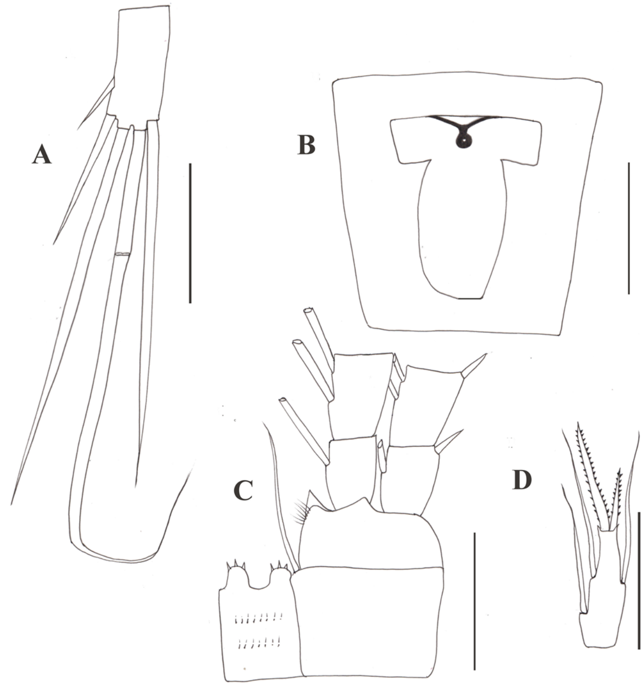
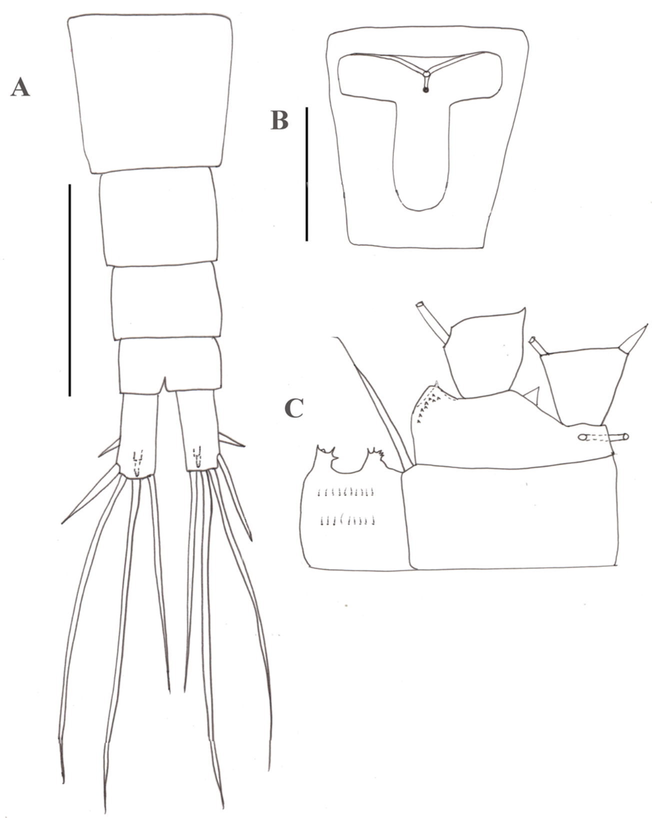


Figure 13. *Thermocyclops crassus* A, Caudal setae; B, Genital double somite and lateral arms of seminal receptacle; C, p4 intercoxal sclerite, exopodite 2-3 and endopodite 2-3, frontal; D, p4 endopodite 3, frontal. (Scale bar= A-C, 50 µm). The voucher specimen is deposited in USTZRC with corresponding reference numbers USTZRC 0176A-B.



al. (2016). The observable occurrences of *T. taihokuensis, T. crassus* and *T. decipiens* documented in this paper together with previous studies done in several inland waters in regions of the Philippines revealed that these species of *Thermocyclops* are the most common types of cyclopoid present in the country (Mamaril, 1986; Mamaril, 2001; Tuyor & Baay, 2001; Papa & Hołyńska, 2013; Dela Paz et al., 2016). Meanwhile, *T. decipiens* which was formerly found in Lakes Sebu, Siloton, and Lahit (Papa & Hołyńska, 2013), is now only recorded in Lake Lahit. Also, the cyclopoid *Mesocyclops augusti* Papa & Hołyńska 2013 which is endemic to Lake Siloton was not collected during our survey. Lake Lahit, on the other hand, did not yield *T. crassus* which was also previously by Papa & Hołyńska (2013). Also, we did not observe the endemic species *Mesocyclops microlasius* Kiefer, 1981in Lake Sebu, South Cotabato which was recorded by Tuyor and Baay (2001).

Sampling effort, presence of predatory fishes such as *O. niloticus* and seasonality of zooplankton may have been some of the causes to explain the absence of some cladocerans and copepods in the study. Since the sampling collection in Panay and Mindanao Is. was conducted during the beginning of the wet season (June 2014) in the Philippines and frequent raining was observed, the sites may have lower species diversity and richness. Low diversity and richness of Cladocera may be attributed to its seasonality which is observably higher during dry and post-rainy seasons than rainy and pre-rainy seasons (Okogwu, 2010). The water qualities such as dissolved oxygen, temperature, and nutrients (phosphate and nitrates) during this sampling month would have decreased and were directly proportional to the number of zooplankton fauna. Predatory copepods feed on phytoplankton which are primarily affected by the variation of water qualities in the area. The density and species of phytoplankton tend to alter when water qualities fluctuate (Winder & Sommer, 2012; Sambitan et al., 2015) subsequently this would influence the number of copepods in the water.

Species richness in Panay and South Cotabato can be considered to be of low figure; drawing attention to that in only 18 out of the 32 sampling sites we observed freshwater microcrustacean zooplankton. Most rivers yielded no zooplankton species, very likely due to the high velocities of rivers since zooplankton tend to be at the mercy of currents (Dela Paz et al., 2016).

Conclusion and Recommendation

Thirteen species of freshwater planktonic microcrustacean were identified from selected freshwater bodies of Luzon Island, Panay Island and South Cotabato, Mindanao Island. This paper presents the first account of the zooplankton composition of Lake Holon and all sampling sites in Panay Island, and updates the previous list of zooplankton species found in Lake Taal, Lakes Sebu, Siloton, and Lahit. Also, this paper provides an update to the wide distribution of the invasive *A. dorsalis* in southern Philippines. *M. ogunnus* is hereby reported for the first time in Lake Taal with *T. crassus*. Seasonality can be cited for the disappearance of some species. Thus, sampling during both dry and wet seasons is recommended for re-assessment and verification of year-round occurence of cladocerans and copepods.

Further study on freshwater planktonic microcrustaceans in unexplored area such as marshes, semi-terrestrial habitats, and ephemeral ponds is recommended to add to the knowledge of Philippine zooplankton biodiversity.

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